"Isotopic Measurements of Sulphonates and Phosphonates and Investigations of Possible Formaldehyde Products from the Murchison Meteorite"

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Work has been completed on the isotopic measurements of organic sulfonates from the Murchison meteorite. A manuscript is in preparation and will be submitted to Science. Below is a summary of the results.

Intramolecular carbon, hydrogen, and sulfur isotope measurements have been made on a homologous series of organic sulfonates discovered in the Murchison meteorite. Mass independent sulfur isotope fractionations were observed along with D/H ratios clearly larger than terrestrial. The sulfur fractionations may be produced chemically and due to molecular symmetry factors. The deuterium enrichments indicate formation of the hydrocarbon portion of these compounds in a low temperature astrophysical environment consistent with that of molecular clouds. The source of the sulfonate precursors may have been the reactive interstellar molecule, CS. Low temperature CS reactions also produce other sulfur containing compounds as well as a solid phase. Isotopic measurements on bulk phosphonates were also made.

Table 1. Results of intramolecular measurements of stable isotopes of sulfur, hydrogen, and carbon from Murchison sulfonates. MSA = methyl sulfonate, ESA = ethyl sulfonate, iPSA = isopropyl sulfonate, nPSA = nor-propyl sulfonate. The hydrogen results are uncorrected for blank and exchangeable hydrogen. Values in parenthesis are the results of a previous experiment and are corrected.

Sulfur

R	$\delta^{33}S$	$\delta^{34}S$	$\delta^{36}S$	$^{33}\Delta$	$^{36}\Delta$
CH_3	2.48	2.49	6.76	1.24	1.85
CH_3CH_2	1.07	2.13	4.8	0.005	0.6
$2(C_3H_7)$	1.04	1.41	---	0.34	---
*Bulk R-SO_3^- 0.19	-0.11	---	-0.14	---	
Standard; MSA	0.45	0.80	2.7	0.05	1.12

Carbon and Hydrogen

R	Compound	$\delta^{13}C$	$\delta D_{uncorrec}$(corrected)
CH_3	MSA	+6.43 (+26)	+204.4 (+708)
CH_3CH_2	ESA	-2.74 (-8)	+415.51 (+778)
$CH_3CH_2CH_2$ nPSA		+1.95 (-2)	+535.63 (+661)
$(CH_3)_2CH$	iPSA ----	-10.80	+65.08 (+)
(Bulk R-SO_3*		+6	+600)
Phosphonates		-20	+219
Standards; MSA		-30/-40	-100
Standard; NBS 22 (-29.7,-118)		-29.8	-122

* A different sample of Murchison

Table 2. Some known reactions of CS. The given temperatures are those at initial deposition of the listed substances and CS. The initial pressures (of CS) range from approximately one to a few mtorr.

Reactant (+ CS)	Products	T(K)	Ref.
CS	C,S solid	53*, 88	(17)
CS	C,S solid, CS_2, CCS, C_3S_2, S, SO_2, OCS, CO, S_2,	83	(31,14)
	C,S solid,	343	(32)
	C,S solid, CS_2	298	(16)
R'RNH	R'RNCHS, CCS, S	195, 238	(15)
NH_3(solid)	N. R.		(18)
CH_3OH	N. R.	195	(15,13)
Fe_2O_3	FeS		(17)
Ni	$Ni(CS)_4$?	10	(31)
M_xO	MS		(17)
O_2, O	OCS,		(12)
X_2, HX	X_3C_3X, $X_3H_3C_3S_3$ (cyclic)		(13)

* The authors used liquid air as the condensing agent for CS. The temperature of liquid air varies with composition, however, under reduced pressure (the authors report a good vacuum), the temperature can be brought to 53K (26). The authors also reported that after 15 minutes the initial white deposit had acquired a brown color, concluding that even at these temperatures the reaction takes place. This implies that the reaction could proceed at even lower temperatures.

Conclusions

The sulfur anomaly in MSA may arise from a symmetric precursor molecule, possibly CS_2. CS_2, other sulfonate precursors, as well as a portion of the carbonaceous solid found in some chondrites, could have been produce from the chemistry of the very reactive and relatively abundant interstellar molecule CS (Table 2).

The very high D/H ratios of meteorite organics is best explained by low temperature (<50K) gas phase and grain chemistry in interstellar clouds where deuterium (D) is concentrated in organic compounds.

Publications

G. W. Cooper, M. H. Thiemens, T. L. Jackson, S. Chang (1996)
Sulfur and hydrogen isotope anomalies in meteoritic sulfonates: possible interstellar CS chemistry. Manuscript in preparation (Science).

G.W. Cooper, S. Chang. (1995) Isotopic measurement of organic sulfonates and phosphonates of the Murchison meteorite. *LPS* **XXVI**, 281-282

Presentations

G. W. Cooper, M. H. Thiemens, T. L. Jackson, S. Chang (1996)
Sulfur and hydrogen isotope anomalies in organic compounds from the Murchison meteorite. ISSOL, Orleans, France.

G. W. Cooper, (1995) Molecular and isotopic analyses of organic compounds from meteorites and ancient sediments. NOBCChE, Los Angeles, CA.

G.W. Cooper, S. Chang (1995) Isotopic measurements on organic compounds from the Murchison meteorite: Indicators of interstellar origin. Gordon Research Conferences, Ventura, CA.